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BULLETIN

OF THE

New York State Museum

VOL. 2. No. 9

AUGUST, 1890

BEAKS OF UNIONIDÆ INHABITING THE VICINITY OF ALBANY, N. Y.

By WILLIAM B. MARSHALL, M. S. (Lafayette)

ASSISTANT ZOOLOGIST

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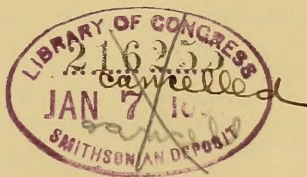
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By WILLIAM B. MARSHALL, M. S. (Lafayette), Assistant Zoologist, New York State
Museum

In many of the older works dealing with the Unionidæ the decortication of the beaks* is mentioned as being a character of specific importance. Lamarck describes it as a generic character. Many later authors, in describing these shells, pass over the characters of the beaks with only casual mention, styling them prominent, undulated, doubly concentric, etc., without directing particular attention to the points of similarity or difference between the beaks of nearly allied species. In many cases the beaks have not been properly figured.

The beaks of the various species of Unionidæ possess characters which are constant and which, in many cases, are sufficient in themselves to distinguish the species. In very young shells the ornamentation of the surface is frequently the only reliable means of specific determination. A few of the species of this family have the beaks perfectly smooth but by far the greater number have the beaks more or less roughened, and these peculiarities of ornamentation are not continued in the later growth of the shell, which may become smooth, as in *Anodonta fluviatilis*, or may

* The word *beak* and its equivalent *umbo* are usually used to designate the extreme tip or apex of each valve of bivalve shells. In the case of the Unionidæ the meaning has broadened to include the undulated area near the hinge-line. In this paper it is the broader meaning which is intended when the words *beak* and *umbo* are used.

For an account of the relation between the umbonal tip or glochidium form and the adult form of Unionidæ the reader is referred to page 365 of a recent paper on The Phylogeny of the Pelecypoda, by Robert T. Jackson, Ph. D. (Mem. Bost. Soc. Nat. Hist., Vol. iv, No. viii, July, 1890).

assume other characters such as spines, as in *Unio spinosus*, or tubercles, as in *U. cornutus*. Difference of sex, although it does not affect the appearance of the very young shell, may cause the female adult to assume a form very different from that of the male.

Due allowance being made for a reduction of size, the form and outline of the young shell are found to agree very closely with the form and outline of the adult, except when the female adult is enlarged to accommodate ova. In those species in which the adult is ornamented with a variety of colors the adult colors as a rule are very different from those of the young. Frequently the beaks, when present in perfection, are stained by some foreign matter in the stream or lake in which the animal lived. In such cases it may be difficult to determine what is the natural color of the beaks. As a rule it may be said that the color of very young specimens when not affected by foreign matter in the water, is a light ashy, or olive grey, the growing shell gradually assuming the colors by which it is known in the adult state.

On the anterior and posterior dorsal areas of the young shells of many species, there will be noticed several elevated fine lines running from the lateral terminations of the undulations towards the beaks. In the text of this paper these lines are called the converging lines of the undulations. In addition to these, there will be noticed several other elevated fine lines radiating from the beaks without a corresponding undulation. If a careful examination of these radiating lines be made it will be seen that they are the converging lines of obsolete or absent undulations. In this paper these lines are called radiating lines. The radiating lines are not continued in the adolescent stage of the shell but terminate abruptly, usually before reaching the point, where in the adult the first line of growth is plainly visible. At the point where adult characters of surface and coloration are assumed, the undulations of the beaks, if continued to that point, abruptly terminate. Thus, externally

at least, the young shell differs from the adult in all particulars except general form.

A person familiar with the adult forms of a species, say *Anodonta fluvialis*, will, when trying to identify the young, naturally appeal to the umbones for some evidence, perhaps the only evidence, to confirm his opinion that he has referred his young shell to the right species. If, by some means, the undulations of the young shell have been eroded, the matter of identification immediately becomes more difficult, and the result, after one has affixed the name to the shell, is looked upon with more or less doubt. With an adult specimen of a described species, any one having access to the literature of the subject may be reasonably sure of being able to come at a correct identification, but with a young shell, one is apt to read description after description, finding, perhaps, a dozen species whose beaks are described as doubly concentric (such as the shell to be named), or undulated and prominent (agreeing with the shell in hand), but finding none described with sufficient accuracy of detail to enable one to reach an exact determination. The finding of a description which appears to fit the case does not always remove the stumbling-block of doubt, for in very few cases can one find accurate figures of the undulations of the young shell. This is due in some measure to the fact that species are often described and figured from imperfect specimens lacking beak characters, and that figures of better specimens have not been substituted for the original in later works.

Dr. Lea, in one of his earliest papers in the Transactions of the American Philosophical Society, mentions the characters of the beaks as being of specific importance, and, in his later writings, he has several times called attention to the importance of these characters. With a view to determining for myself the value of the beaks in making specific discriminations, I have carefully examined the beaks of perfect or nearly perfect specimens of all the Unionidæ inhabiting the vicinity of Albany. Descriptions and figures of each

will be found in this paper. A study of the shells of such a limited area cannot lead to any broad conclusions and such conclusions as are drawn must necessarily be of local application. The following statement may be made as being applicable to all the species found in this vicinity:—They have the beaks ornamented with undulations of the surface, and these undulations are constant in each species, and are sufficient in themselves to distinguish each from every other species inhabiting this neighborhood.

For practical purposes of identifying adult specimens the beaks are of little value in some species as they are usually eroded to such an extent as to have lost all trace of their original appearance, and, in most cases, the adult characters are sufficiently distinct to determine the species. With young shells the case is different. The undulations are rarely eroded to such an extent as to have lost their distinctive characteristics, and, as has been said, the undulations are in some cases the only sure means of identification.

Among the characters which are common to the beaks of most species should be mentioned here the fine concentric striæ which crowd the surface of the young. In the following descriptions no notice of this character will be taken unless some variation worthy of particular mention be observed. It may be remarked that these striæ are merely upon the epidermis while the undulations are in the calcareous matter of the shell. The striæ do not run parallel with the undulations but parallel with the nearest growth lines of the shell and necessarily they cross the undulations. In a less marked degree the striæ may be seen throughout the growth of the shell to the adult state.

Another feature which may be said to be common to all the species is the location of the highest and broadest portion of each undulation. It is on the ridge running from the beak to the posterior ventral angle of the shell. This ridge represents the line of maximum growth of the shell so that the undulations of the beaks in their line of maximum growth coincide with the line of maximum growth of the shell.

A list of the species inhabiting the vicinity of Albany is given below, arranged in the same order of sequence as in Lea's Synopsis of the Unionidæ :

GENUS MARGARON

Subgenus UNIO

Symphynote, smooth, oblong — U. PRESSUS, Lea.....	Syn. p.	29
Non-symphynote, smooth, oval — " OCHRACEUS, Say.....	" "	42
" " " " — " CARIOSUS, Say.....	" "	42
" " " " — " LUTEOLUS, Lam.....	" "	44
" " " " — " RADIATUS, Lam.....	" "	44
" " " oblong — " COMPLANATUS, Sol.....	" "	51
" " " wide — " NASUTUS, Say.....	" "	60
" " " obovate — " TAPPANIANUS, Lea.....	" "	62

Subgenus MARGARITANA

Non-symphynote, plicate, oblong — M. MARGINATA, Say.....	" "	67
" " " " — " RUGOSA, Barnes.....	" "	67
" " smooth, triangular — " UNDULATA, Say	" "	68

Subgenus ANODONTA

Non-symphynote, smooth, oval — A. UNDULATA, Say.....	" "	79
" " " " — " IMPLICATA, Say.....	" "	80
" " " " — " FLUVIATILIS, Dillw.....	" "	80
" " " " — " LEWISII, Lea.....	" "	80
" " " wide — " SUBCYLINDRACEA, Lea.....	" "	82

For the synonyms of the above species the reader is referred to Lea's Synopsis at the pages indicated to the right in the above list.

In the text of this paper the species are considered in the order of sequence indicated by the relationship of beak characters. Arranged upon this basis the species of the foregoing list fall into the following order :

- } UNIO PRESSUS, Lea
- } UNIO TAPPANIANUS, Lea
- } UNIO LUTEOLUS, Lam.
- } UNIO RADIATUS, Lam.
- UNIO NASUTUS, Say
- UNIO COMPLANATUS, Sol.
- } UNIO OCHRACEUS, Say
- } UNIO CARIOSUS, Say
- } MARGARITANA MARGINATA, Say
- } MARGARITANA RUGOSA, Barnes
- MARGARITANA UNDULATA, Say

ANODONTA UNDULATA, Say

ANODONTA SUBCYLINDRACEA, Lea

ANODONTA IMPLICATA, Say

{ ANODONTA FLUVIATILIS, Dillw.

{ ANODONTA LEWISII, Lea

The resemblance between the beaks of *U. pressus*, Lea, and *U. Tappanianus*, Lea; between *U. luteolus*, Lam., and *U. radiatus*, Lam.; between *U. ochraceus*, Say, and *U. cariosus*, Say, supported by resemblances between other characters of the shells seems to warrant the supposition that the two members of each pair are closely related. The beaks of *U. nasutus*, Say, resemble in some measure those of *U. radiatus*, Lam., but the two shells have very little resemblance in other specific characters. *U. complanatus*, Solander, differs both in beak and other characters, from the other Unios of the vicinity.

Among the Margaritanæ of this neighborhood a distinct relationship exists between the beaks of *M. marginata* and *M. rugosa*, and in the adult state these two species are more or less related because of the corrugations on the posterior dorsal area. *M. undulata*, Say, in its beak characters differs greatly from both of the preceding species, but there is no close resemblance in other features existing between the latter and the two former which would lead one to anticipate a corresponding resemblance of beaks.

Among the Anodontæ a slight resemblance exists between the beaks of *An. undulata*, Say, and *An. subcylindracea*, Lea, but the resemblance is not at all marked. A marked relationship exists between *An. fluviatilis*, Dillw., and *An. Lewisii*, Lea, both in beak and other characters. According to some of its conchological features, *An. implicata*, Say, is related to *An. fluviatilis*, Dillw., but the undulations of the beaks of the two species differ materially.

By far the greater portion of the material used in the preparation of this paper was drawn from the collection of

shells presented to the State Museum in 1886, by C. E. Beecher, now in charge of the Department of Invertebrate Palæontology in Yale University Museum. The collection is rich in immature stages of Unionidæ, and in adult specimens of the same family with beak characters well preserved. Of the eighteen specimens figured on the plate, fifteen are from this collection.

The Gould, Emmons, Aldrich, Lewis and Gebhard collections have furnished much fine material for comparison, all identified and labelled by the late Dr. James Lewis of Mohawk, N. Y. The figured specimens of *U. Tappanianus* and *M. rugosa* are from the Aldrich and Gould collections respectively. The specimen of *An. subcylindracea* shown in fig. 13 is from the Lewis collection.

UNIO PRESSUS, Lea

Fig. 1

Beaks with four or five prominent undulations, which are acutely angular and high posteriorly; rounded and lower anteriorly; each undulation having a deep sinus on the ventral side back of the middle and plainly visible converging lines both anteriorly and posteriorly. Dorsal areas with several elevated, radiating lines, curved and wavering and somewhat interrupted on the anterior area; direct and continuous on the posterior area. Anteriorly the converging lines and radiating lines are much stronger than posteriorly.

The beaks of this shell are usually more or less decorticated, but in few cases only are the undulations themselves eroded. The undulations are rather obcordate, with the anterior wing larger and less angular than the posterior wing. The sinus in the undulations of the beak is frequently indicated throughout the growth of the shell from the young to the adult, in the form of a slight linear depression traversing the shell from the beaks either to the middle of the ventral margin or to a point immediately in front of the posterior ventral angle. This species is nearly related to *Unio Tappanianus*, Lea.

UNIO TAPPANIANUS, Lea

Fig. 2

Beaks with four or five undulations, each having a prominent sinus on the ventral side about the middle, and plainly visible converging lines both anteriorly and posteriorly. Dorsal areas with several fine, direct, uninterrupted radiating lines.

The beaks of this species very closely resemble those of *Unio pressus*, Lea, but the undulations are proportionally stronger and are placed nearer the tip of the beak, and the sinus is more nearly medial and not so deep. The radiating lines on the anterior dorsal area are straight, sharply defined against the surface of the shell and come to an abrupt termination. Those of *U. pressus* are not so sharply defined, are curved and wavering and gradually become obsolete.

Dr. Lea, in his Synopsis of the Unionidæ, has the two species widely separated, the one, *U. Tappanianus*, arranged under non-symphynote, smooth, obovate Unios, and the other, *U. pressus*, under symphynote, smooth, oblong Unios. So far as this classification relates to *U. Tappanianus*, it is erroneous. I have specimens of *U. Tappanianus* which are symphynote for one-half or two-thirds the length of the hinge-line. The possession of this character alone would be sufficient to place *Tappanianus* near to *pressus* in a systematic arrangement. Judged by the characters of the beaks alone these two species appear to be closely related, and there is no great difference in form or outline or other characters of the shells to gainsay this evidence of the beaks. *U. Tappanianus* is, perhaps as a rule, a more obese shell than *U. pressus*, but the latter is sometimes quite as obese as the former.

Many growing and adult specimens of *U. Tappanianus* show a linear depression of the surface of the shell from the sinus in the undulations of the beaks to the middle of the ventral margin. In all the specimens examined the depres-

sion, when present, was located as described above. In *U. pressus* the depression may run either to the middle of the ventral margin or to a point immediately in front of the posterior ventral angle.

The beaks of all the specimens of this species which have come under my observation are more or less eroded, but in almost all cases the characters described above can be plainly traced.

UNIO LUTEOLUS, Lam.

Fig. 3

Beaks with seven to ten undulations, each with a prominent irregular sinus on the ventral side about the middle. The undulations lack converging lines and the dorsal areas lack radiating lines. The undulations are rounded and continuous in front, deflected at the sinus in the direction of the posterior ventral angle of the shell. Posteriorly, the later undulations are wavering and interrupted and terminate abruptly at the ridge running from the beak to the posterior ventral angle. The last two or three undulations are very weak anteriorly.

In this species the number of undulations is variable. As a rule the later undulations are more or less interrupted and wavering and the sinus weak, but the earlier undulations are regular and continuous and have the sinus prominent. The undulations of a specimen from Rockford, Ill., are so broken and wavering as to give the surface of the young shell a granulated appearance. A great difference in relative coarseness of the undulations may be observed in different specimens. In some they are more numerous, very fine and placed close to each other, giving a rippled appearance. In others they are fewer in number, coarse, and rather widely separated. The beaks of this species are usually eroded but many perfect specimens can be easily obtained. *U. luteolus* in beak and other characters is closely

related to a number of Unios, among which may be mentioned *U. radiatus*, *U. spatulatus*, and *U. ligamentinus*.

U. luteolus differs from *spatulatus* and *radiatus* in the number of undulations and in the area occupied by them. In the first the undulations are more numerous and extend over a large area; in the two latter they are fewer and occupy a very limited area close to the tip of the beak. From *U. ligamentinus* it differs in having more undulations and in having a deeper sinus. In *U. luteolus* the undulations do not continue up the anterior dorsal area while in *U. ligamentinus* they continue up the anterior area nearly to the hinge-line.

UNIO RADIATUS, Lam.

Fig. 4

Beak with six undulations, the first four of which have a prominent sinus about the middle. The last two undulations are interrupted at the middle, and the portion anterior to the interruption slightly overlaps the portion posterior to the interruption — the anterior portion being nearer to the beak than the posterior portion. Posteriorly, each undulation has a fine but prominent converging line. Anteriorly, there are no converging lines of the usual type but the undulations are rounded and continue up the anterior area nearly to the hinge-line. Dorsal areas without radiating lines.

The above description is taken from a single specimen of which one valve only is nearly perfectly preserved. The specimen was secured by a careful search through several hundred specimens of all ages and from many localities. The undulations described are contained in a space a little more than $\frac{1}{16}$ in. wide and a little more than $\frac{1}{8}$ in. long. A very sharply defined line of growth marks the boundary of the space containing the undulations. Outside of this boundary there are two very slight elevations of the surface of the shell parallel to the undulations but I am unable to

decide whether these elevations are or are not of the same nature as the undulations. For this reason, and because of the small area occupied by the undulations, which, to me, appears to be abnormally small, I fear that the description will not answer for any specimens other than the one from which the description is taken.

UNIO NASUTUS, Say

Fig. 5

Beaks with five or six undulations which are rounded on the summit and placed nearly parallel to the hinge-line. Each undulation has a prominent sinus on the ventral side back of the middle. Posteriorly, the first and second undulations have very faint converging lines; remaining undulations lacking converging lines and posterior dorsal area lacking radiating lines. Anteriorly, the undulations have no converging lines of the usual type but the undulations are rounded and continue up the anterior dorsal area nearly to the hinge-line. Posteriorly, the undulations, except the first and second, terminate at the ridge traversing the shell from the beak to the posterior ventral angle. On the posterior area the concentric striæ are very numerous and much more prominent than elsewhere. In most of the very young specimens there may be seen two slight depressions of the shell along the posterior dorsal area — these depressions are continued throughout the growth of the shell.

The undulations of the beaks of *U. nasutus* resemble, in some measure, those of *U. radiatus*, Lam., while a much closer resemblance exists between the former and *U. luteolus*, but the outline of the young *nasutus* differs so much from the outlines of the other two that the shell cannot be mistaken for either of them. Notwithstanding the similarity of beak characters existing between *U. nasutus* and *U. luteolus* and *U. radiatus* the great differences in the other characters of the shells do not permit the supposition that the former is closely related to either of the latter.

UNIO COMPLANATUS, Sol.

Fig. 6

Beaks with four to six sharp undulations, which are rounded anteriorly and angular posteriorly, and which have fine, direct converging lines on both dorsal areas. Lateral portion of each undulation placed nearly parallel to the hinge-line, and not much stronger posteriorly than anteriorly. Undulations without any indication of a sinus, and dorsal areas without radiating lines.

The beaks and other characters of *U. complanatus* do not indicate any near relationship with any other species of *Unio* inhabiting this vicinity. The species is, however, closely related to *U. declivis* in all characters. Dr. Lea in his Synopsis has these two species separated by several pages. Although both are arranged under the same group, it would be better if they were placed nearer to each other in the group.

Although *U. complanatus* is one of the most plentiful species in this neighborhood, it is not easy to secure specimens having good beaks.

UNIO OCHRACEUS, Say

Fig. 7

Beaks with six or seven undulations which are rounded on the summit and placed nearly parallel to the hinge-line. None of undulations have a distinct sinus, but there is sometimes a slight bend toward the beak about the middle of the earlier undulations. Posteriorly, the earlier undulations have very faint converging lines. Anteriorly, there are no converging lines but the undulations are rounded and continue up the anterior area nearly to the hinge-line. The dorsal areas lack radiating lines. In most cases there are two slight, linear depressions of the posterior dorsal area which are continued in the later growth of the shell. Usually the very young shell shows the bright green rays which are generally present in the adult state, and in such

cases the rays may be seen to begin quite close to the tip of the beak.

U. ochraceus is easily distinguished from its near relative, *U. cariosus*, by the much less prominent converging lines of the earlier undulations on the posterior dorsal area and by the lack of converging lines for the later undulations. The undulations of *U. cariosus* are sharp on the summits and the posterior lateral portion of each undulation is much stouter than any other portion. The undulations of *U. ochraceus* are round upon the summits and the undulations are not decidedly stouter at one point than at another. Another difference is in the direction of the undulations. If the lateral portions of the undulations of *U. cariosus* were extended they would intersect the hinge-line posterior to the beaks while the undulations of *U. ochraceus* if extended would either intersect the hinge-line anterior to the beaks or simply maintain a parallel course with the hinge-line. *U. ochraceus* presents two entirely different phases of coloration, and in this respect the young form agrees with the adult form.

Not uncommonly, the color is a plain straw-yellow both in the young and in the adult shell. More generally, the ground color is a straw-yellow beautifully ornamented with rays of bright green. In such cases the green rays extend nearly to the tip of the beak, passing over the undulations. This feature, which is common in *U. ochraceus* is not at all common to other species of Unionidæ. A careful examination of numerous specimens of *U. cariosus* failed to secure an individual which had the adult characters of color distinctly shown in the very young shell.

Owing to the thin epidermis and fragile nature of the shell the beaks of *U. ochraceus* are usually much eroded, even in specimens taken from very quiet and very pure waters.

UNIO CARIOSUS, Say

Fig. 8

Beaks with six or seven undulations, which are rounded and lower in front, acutely angular and elevated posteriorly. First two or three minute undulations either interrupted about the middle or making, at that point, a decided bend toward the tip of the beak. The remaining undulations make a slight bend at the middle toward the tip of the beak. Anteriorly, the undulations lack converging lines, but the undulations themselves continue up the anterior area almost to the hinge-line. Posteriorly, the undulations have converging lines, which, relatively to the strength of the undulations are very weak. Dorsal areas without radiating lines.

This species is closely related to *U. occidentis*, Lea, and more remotely to *U. ochraceous*, Say, and *U. multiradiatus*. The beaks are usually much eroded. Out of numerous specimens from this and other localities only two had the beaks perfect. Both specimens are from Norman's Kill. The specimens from this locality, as a rule, have the umbones better preserved than those from other localities. Many can be obtained of which only the epidermis has been worn off, exposing the calcareous matter of the shell, but retaining the distinctive features of the undulations.

From *U. occidentis*, which this species resembles very closely, it may be distinguished by the great difference in the strength of the undulations, which are sharp on the summit and very high in *U. cariosus*, while in *U. occidentis* they are rounded on the summit and lower. On the anterior dorsal area of the two shells no difference is apparent, but posteriorly the prominent converging lines of *U. cariosus* mark an important difference. In *occidentis* the converging lines are absent or obsolescent.

U. cariosus differs from *U. multiradiatus* in having the undulations more widely separated one from another, and

more elevated posteriorly, in showing less distinct indications of a sinus in several of the undulations and in having the summits of the undulations sharp instead of rounded.

Under the description of *U. ochraceus* the points of resemblance and difference between *U. cariosus* and *U. ochraceus* are pointed out.

MARGARITANA MARGINATA, Say

Fig. 9

Beaks with three or four very coarse and rude undulations, which are placed nearly parallel to the hinge-line. Each undulation with a gently curving sinus on the ventral side and very fine converging lines both anteriorly and posteriorly. The converging lines of the first two undulations are plainly visible; those of remaining undulations are nearly obsolete. The posterior lateral portion of the last undulation is usually obsolete. Dorsal areas without radiating lines.

Perfect specimens of this species may be easily secured. As a rule the Margaritanæ of this vicinity suffer much less erosion than the Unios or Anodons, and this statement appears to hold good for other localities.

In many specimens of this species the sinus in the undulations of the young shell is indicated in the adult by a depression of the surface of the shell from the beak to the middle of the ventral margin and by a slight bend in the margin. The posterior dorsal area of the young shell sometimes shows the corrugations which are characteristic in the adult.

This species is closely related in beak characters to *M. fabula*. Dr. Lea, in his disposition of these two species, gives another example of the artificial character of the last division of his classification, viz.: the grouping according to shape of outline. *M. marginata* is placed under plicate, oblong Margaritanæ, and *M. fabula* under smooth, arcuate. Although the two species differ materially in the nature of

the posterior dorsal area, which is plicate in *M. marginata* and smooth in *M. fabula*, and should perhaps be divided according to this difference, yet the relation of the undulation of the beaks is of much more importance than the mere slight difference of outline. The grouping should aim to show the relation of the beaks.

The differences between the beaks of *M. marginata* and *M. fabula* are so slight that it is difficult to point them out. The only absolute difference between the two is in the length of the lateral portions of the undulations and modifications dependent upon this difference. In *M. fabula* the lateral portion of each undulation is somewhat (about one-third) shorter than the lateral portion of the corresponding undulation of *M. marginata*; the sinus in the second undulation is not so prominent, and the posterior lateral extremity of each undulation lacks the long and gentle slope which is so striking in *M. marginata*.

MARGARITANA RUGOSA, Barnes

Fig. 10

Beaks much less strongly undulated than in *M. marginata* or *M. undulata*. There are three or four undulations, the first three of which posteriorly, are acutely angular and elevated; anteriorly, they are less acutely angular and lower, and each undulation, except the last, has plainly visible, though very weak, converging lines, anteriorly and posteriorly. Dorsal areas without radiating lines. First and second undulations each with a sinus; third, either lacking the sinus or showing only slight indications of it; fourth undulation, when present, nearly obsolete, lacking sinus and converging lines.

The young shell shows no indication of the corrugations on the posterior dorsal area which are characteristic of the species in the adult state. A marked relationship exists between the beaks of this species and those of *M. marginata*, and this relationship is further strengthened by the corru-

gations on the posterior dorsal area of both shells in the adult state.

MARGARITANA UNDULATA, Say

Fig. 11

Beaks with four very prominent undulations, which are angular and much elevated posteriorly, rounded and low anteriorly, and each undulation with very prominent converging lines on both dorsal areas. Posterior dorsal area with several straight and continuous radiating lines; anterior area with one or two slightly curved, more or less interrupted radiating lines. Surface of the young shell with many concentric striæ which are most numerous on the summits and ventral slopes of the undulations.

The undulations of this species in connection with the converging lines are essentially triangular.

A distinct relationship of beak and other characters exists between this species and *M. triangulata* and *M. deltoidea*.

The differences between *M. undulata* and *M. triangulata* are very slight. In the former the undulations extend over a larger area and are much more elevated posteriorly than in the latter. The radiating lines on the dorsal areas are more numerous in *triangulata* than in *undulata*.

The undulations of *M. deltoidea*, though very closely resembling those of *M. triangulata* and *M. undulata*, are much less stout.

The specimens of *M. undulata* from Norman's Kill are by far the most beautiful I have seen. The general characters of the species, with the exception of color are nearly the same throughout the state. In most of the localities this species is dark brown or nearly black with slight indications of rays of green and yellow. Those from Norman's Kill have a brilliant green and brown ground color traversed by rays of darker green and bright yellow. As a rule the specimens from Norman's Kill are less stout, less

thickened on the anterior margin and more delicately finished in all particulars than those from the other localities in the state. The beaks in Norman's Kill specimens are more nearly in the middle of the hinge-line than in specimens from other localities.

ANODONTA UNDULATA, Say

Fig. 12

Beaks with four prominent undulations, which are placed very obliquely with reference to the hinge-line, and which are rounded anteriorly and angular posteriorly. Posteriorly, the undulations have very prominent, straight, continuous converging lines. Anteriorly, the converging lines, though distinct, are much less prominent. Dorsal areas with several straight radiating lines which are more prominent posteriorly than anteriorly.

The undulations of the beaks of this species very closely resemble those of *An. edentula*, but careful comparison of the two species will reveal several slight differences. The fine radiating lines on the posterior dorsal area are more prominent and more numerous in *An. edentula* than in *An. undulata*, and the former has more distinct radiating lines on the anterior dorsal area. The most important difference between the two species is in the relative positions of the undulations. In *An. edentula* the stoutest portion of each undulation is nearly parallel to the hinge-line, while in *An. undulata* the stoutest portion of each undulation is decidedly oblique with reference to the hinge-line.

The differences between the beaks of *An. undulata* and *An. Ferrusaciana* are slight. The latter is intermediate between *An. undulata* and *An. edentula*. The undulations of *Ferrusaciana* are not so strong as those of the two species just mentioned; the posterior converging lines are extremely fine; and the anterior converging lines are obsolete. The posterior dorsal area has many radiating lines much finer and more numerous than in *An. undulata*; the anterior area shows no trace of radiating lines.

ANODONTA SUBCYLINDRACEA, Lea

Fig. 13

Beaks with three or four very fine undulations, which are rounded posteriorly and are placed very obliquely with reference to the hinge-line. Posteriorly, the undulations have fine, direct converging lines, and the posterior dorsal area has several fine radiating lines; anteriorly, the undulations terminate abruptly, and the anterior dorsal area lacks radiating lines.

Held with the anterior margin toward the observer and slightly elevated, with the beak pointing over the shoulder, the resemblance of the undulations to the point and first three ascending threads of an ordinary screw is very striking. To simply say that the undulations of this species are spirally arranged would be sufficient to distinguish it from all other Anodons found in this vicinity.

ANODONTA IMPLICATA. Say

Fig. 16

Beaks with five or six undulations, which are rounded on the summits and placed parallel to the hinge-line. Each of the first three or four undulations has a gentle sinus on the ventral side back of the middle. The last two undulations lack the sinus. Posteriorly, each undulation has a very prominent converging line; anteriorly, converging lines are lacking, but the undulations themselves continue up the anterior area nearly to the hinge-line. Dorsal areas without radiating lines.

In adult characters *An. implicata* resembles *An. fluviatilis* so closely that one would naturally expect to find a very close resemblance between their umbonal characters. Such is not the case however. A very deep sinus in each undulation, of which the angle is very acute and in the direction of the tip of the beak, is the most prominent beak character of *An. fluviatilis*, and one which holds the atten-

tion at first glance. None of the undulations of *An. implicata* have a deep sinus. The sinus, in the earlier undulations, is very gentle, and in the later undulations it is absent.

Cases in which there is a striking similarity in adult features between two species, such as that between *An. implicata* and *An. fluviatilis* sometimes afford apt illustrations of the importance of the undulations in making specific determinations. Typical specimens of the two species are easily distinguishable by their form. All specimens are not typical however, and a trifling variation in the characters of *An. fluviatilis* or *An. implicata*, added to loss of umbonal features by erosion or otherwise, is sometimes sufficient to make each practically indistinguishable from the other. When the undulations of the umbones are present there can be no room for doubt in making an identification.

ANODONTA FLUVIATILIS, Dillw.

Fig. 17

Beaks with five to seven fine undulations, which are acutely angular posteriorly and gently rounded anteriorly. Each undulation with a prominent sinus on the ventral side about the middle, of which the angle is acute and in the direction of the beak. Posteriorly, the undulations have plainly visible converging lines. Anteriorly, no converging lines are present, but the undulations continue up the anterior area nearly to the hinge-line. Posterior dorsal area with faint indications of one or two radiating lines. In the lateral portions the undulations are scarcely more elevated at one point than at another.

This species and the following, *An. Lewisii*, are related to a large group of Anodons, among which may be mentioned *An. plana*, *decora*, *ovata*, *Benedictii*, *Footiana*, etc. As it would add unduly to the length of this paper, no attempt is made to point out the differences between *An. fluviatilis* and its near relatives; but under the next species the distinctions between the beaks of *An. fluviatilis* and *An.*

Lewisii are noticed. It is believed that several of the species of the foregoing group should be referred to *An. fluviatilis*.

ANODONTA LEWISII, Lea

Fig. 18

Beaks with four or five undulations which are acutely angular and high posteriorly; rounded and lower anteriorly. First two undulations continuous; later undulations with a moderate sinus back of the middle and nearly interrupted at that point. Anteriorly, there are no converging lines, but the undulations continue up the anterior area a short distance; posteriorly, converging lines are prominent. Dorsal areas without radiating lines.

In form, color and other usually described specific characters, this species is sometimes absolutely indistinguishable from *An. subcylindracea*, but the very great differences in the characters of the beaks of the two species afford easy means of separating them.

Fig. 14 of the plate represents an adolescent specimen of *An. subcylindracea* which cannot be distinguished from *An. Lewisii* by any character but the ornamentation of the beaks.

Fig. 15 is taken from a rather young specimen of *An. Lewisii* for comparison with the above.

A comparison of the beak of fig. 14 with the figures of the beak of *An. subcylindracea* and *An. Lewisii* will show at once that the specimen belongs to the former species.

On the other hand, the beaks of *An. Lewisii* bear some resemblance to those of *An. fluviatilis*, but there are differences which serve to distinguish the two species. In *An. Lewisii* the undulations of the beaks are fewer in number, more widely separated and much stronger than in *An. fluviatilis*. In *An. Lewisii* the later undulations become so weak at the sinus that the part posterior to this point has the appearance of a granule. In *An. fluviatilis* the undulations at the sinus do not materially differ from the portions immediately anterior and posterior to the sinus.

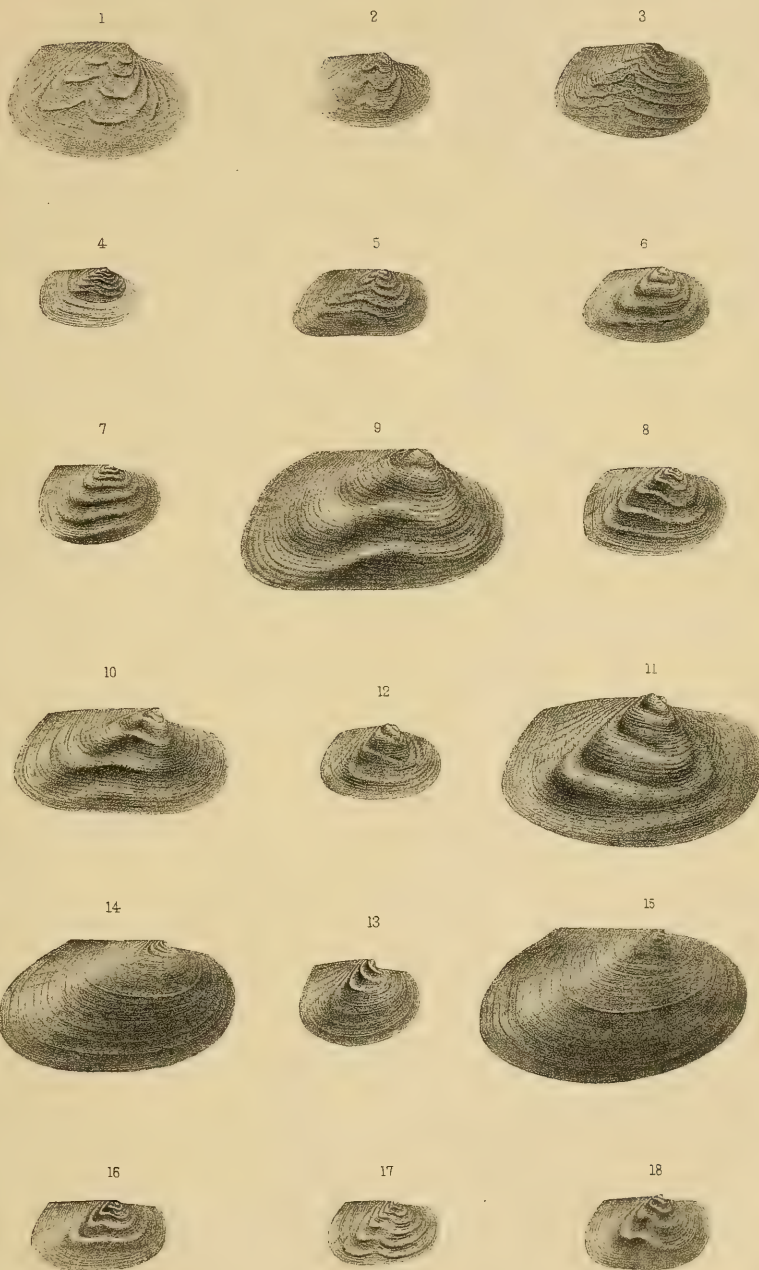
EXPLANATION OF THE PLATE

NOTE:— All the figures, with the exception of figs. 14 and 15, are twice enlarged.
The specimens shown in figs. 2, 10 and 13 are from the Aldrich, Gould and Lewis collections respectively. All the other specimens figured are from the Beecher collection.

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